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(54) **MOLD MACHINING METHOD AND MOLD MACHINING SYSTEM FOR COMPUTER NUMERICAL CONTROL**

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(22) Filed: **Oct. 18, 2012**

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(30) **Foreign Application Priority Data**

Jul. 16, 2012 (TW) .... 101125531 A

(51) **Int. Cl.**

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G06F 19/00	(2011.01)
B29C 39/00	(2006.01)
B05C 11/00	(2006.01)
B05C 13/00	(2006.01)
B05C 13/02	(2006.01)
G06F 17/50	(2006.01)
G05B 19/4097	(2006.01)

(52) **U.S. Cl.**
CPC ***G05B 19/4097*** (2013.01)

(58) **Field of Classification Search**
CPC G05B 19/40; G05B 2219/00; B44B 3/00; G06F 19/00; B05C 5/02; B05B 13/04
USPC 700/2, 95, 98, 119, 159, 160, 193, 197; 118/66, 67; 703/1
See application file for complete search history.

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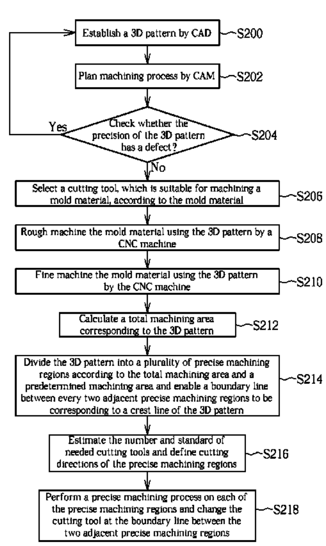
(57) **ABSTRACT**

A mold machining method for computer numerical control includes steps of establishing a 3D pattern; performing an initial machining process on a mold material by the 3D pattern; calculating a total machining area corresponding to the 3D pattern; dividing the 3D pattern into a plurality of precise machining regions according to the total machining area and a predetermined machining area and enabling a boundary line between every two adjacent precise machining regions to be corresponding to a crest line of the 3D pattern; and performing a precise machining process on each of the precise machining regions and changing a cutting tool at the boundary line between every two adjacent precise machining regions.

8 Claims, 9 Drawing Sheets



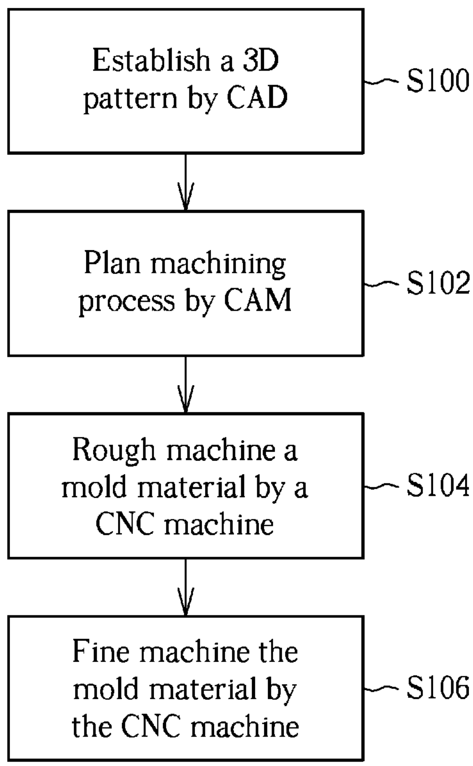


FIG. 1 PRIOR ART

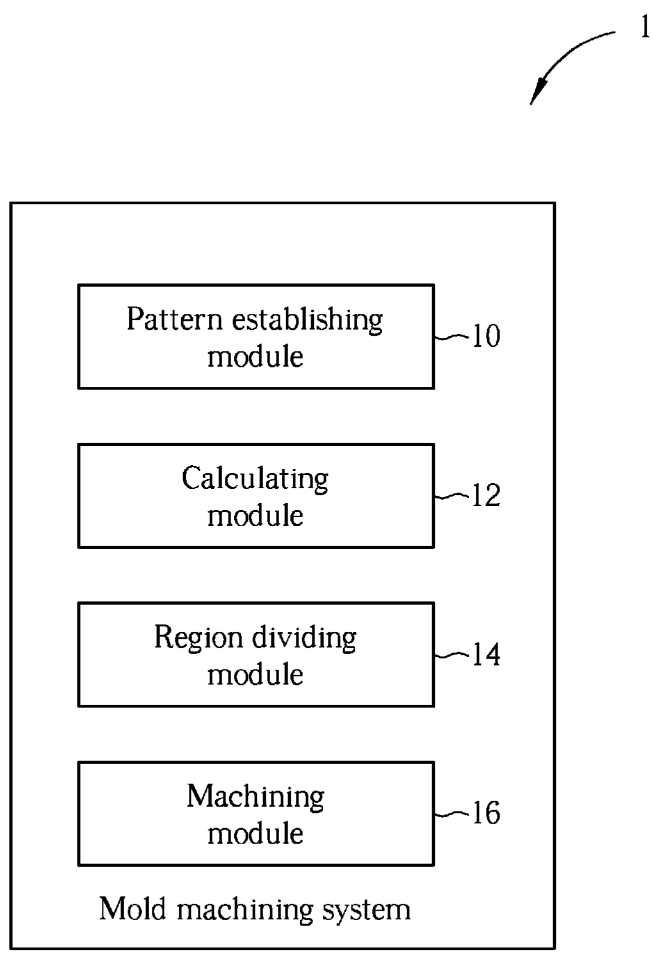

1
Pattern establishing module
10
Calculating module
12
Region dividing module
14
Machining module
16
Mold machining system

FIG. 2

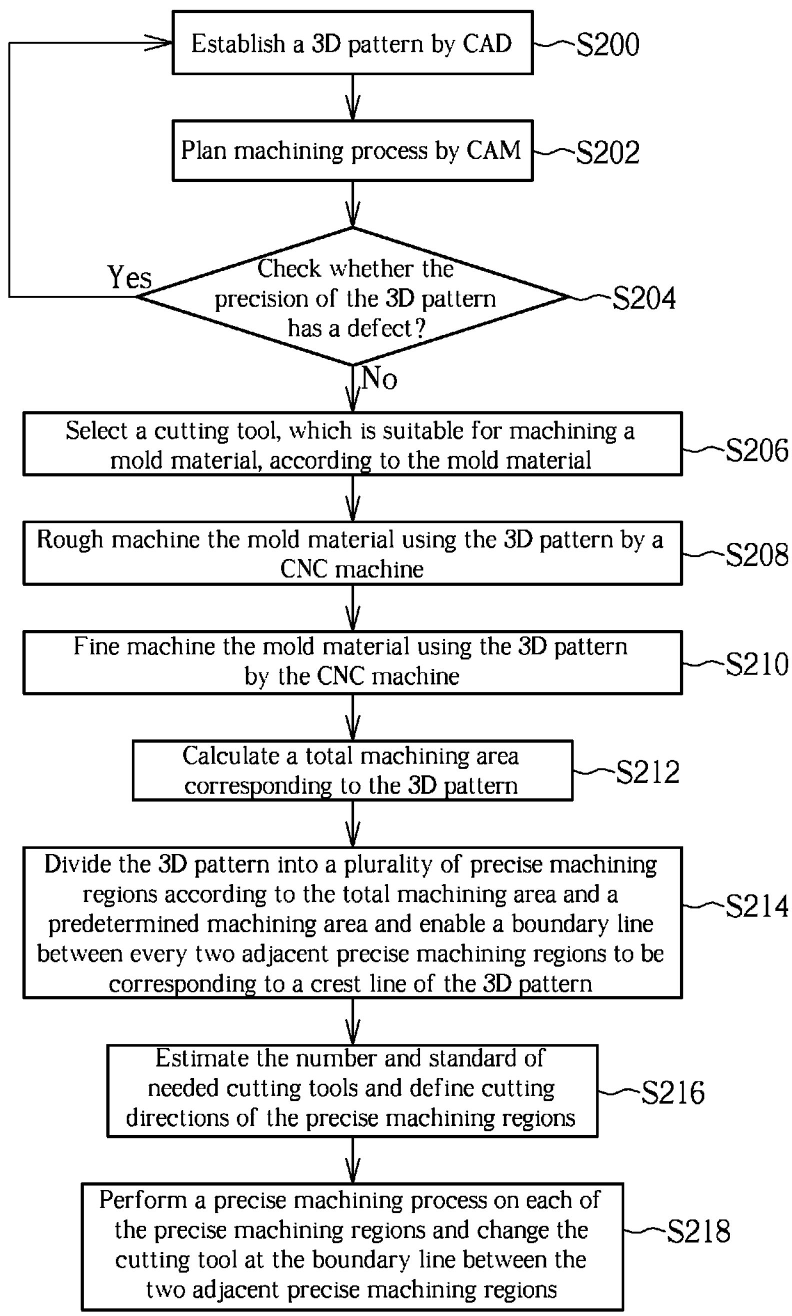

Establish a 3D pattern by CAD
S200
Plan machining process by CAM
S202
Check whether the precision of the 3D pattern has a defect?
S204
Yes
No
Select a cutting tool, which is suitable for machining a mold material, according to the mold material
S206
Rough machine the mold material using the 3D pattern by a CNC machine
S208
Fine machine the mold material using the 3D pattern by the CNC machine
S210
Calculate a total machining area corresponding to the 3D pattern
S212
Divide the 3D pattern into a plurality of precise machining regions according to the total machining area and a predetermined machining area and enable a boundary line between every two adjacent precise machining regions to be corresponding to a crest line of the 3D pattern
S214
Estimate the number and standard of needed cutting tools and define cutting directions of the precise machining regions
S216
Perform a precise machining process on each of the precise machining regions and change the cutting tool at the boundary line between the two adjacent precise machining regions
S218

FIG. 3

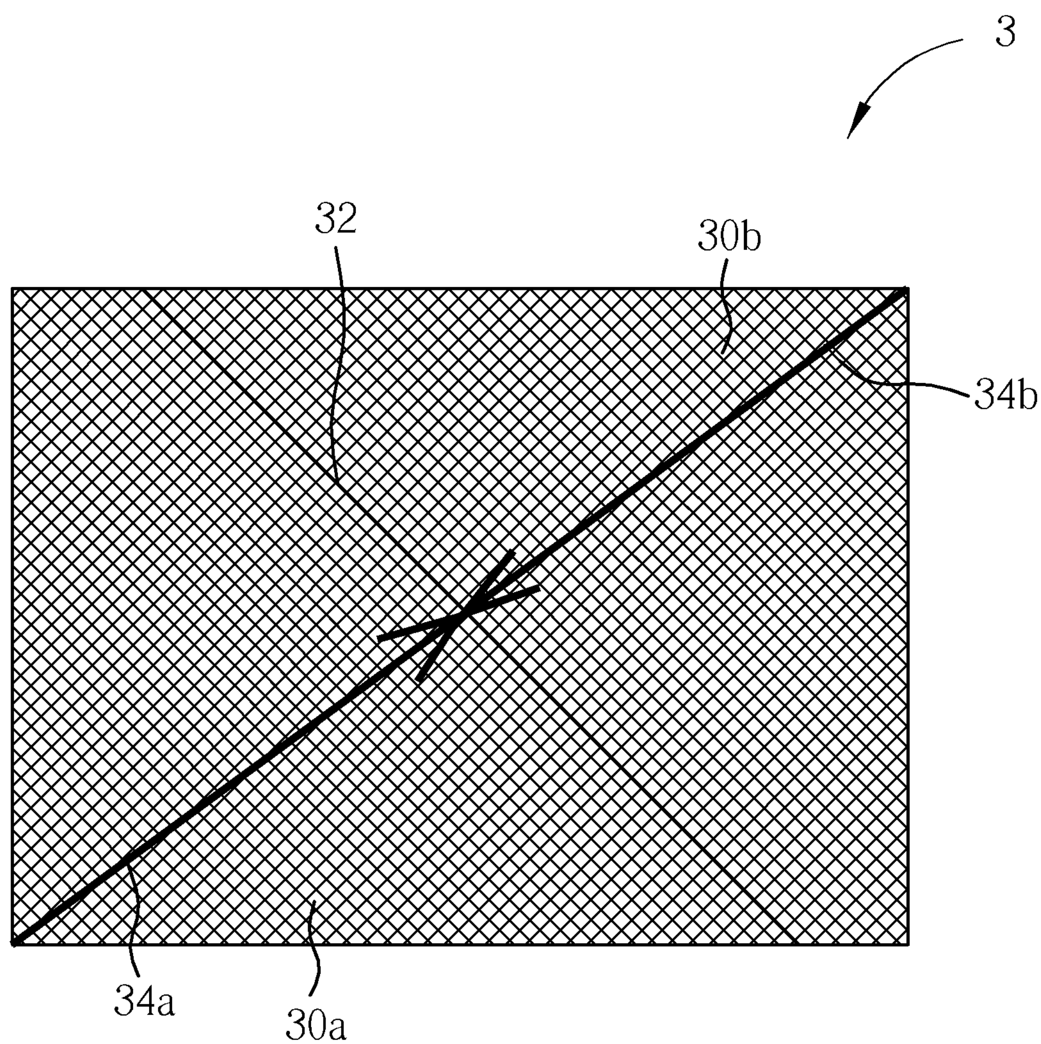


FIG. 4

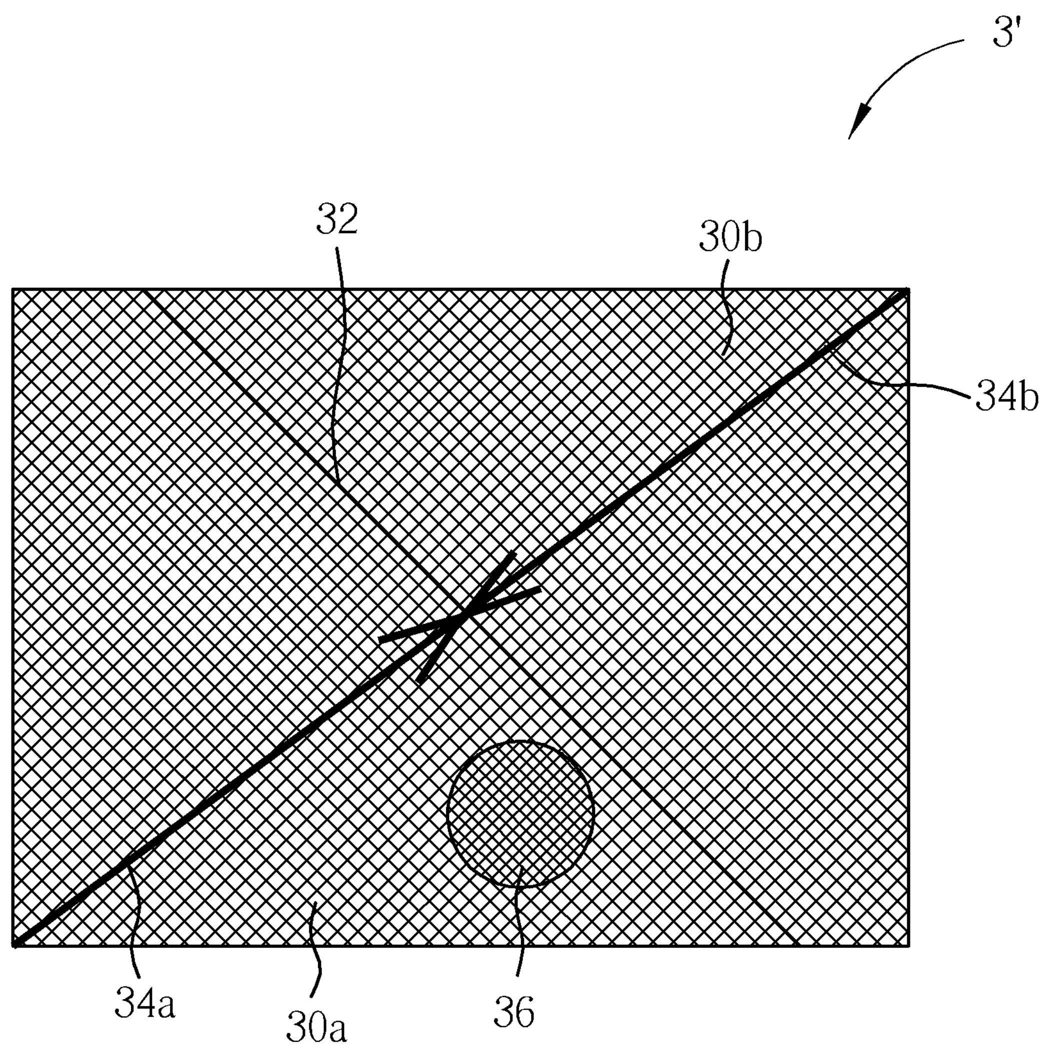


FIG. 5

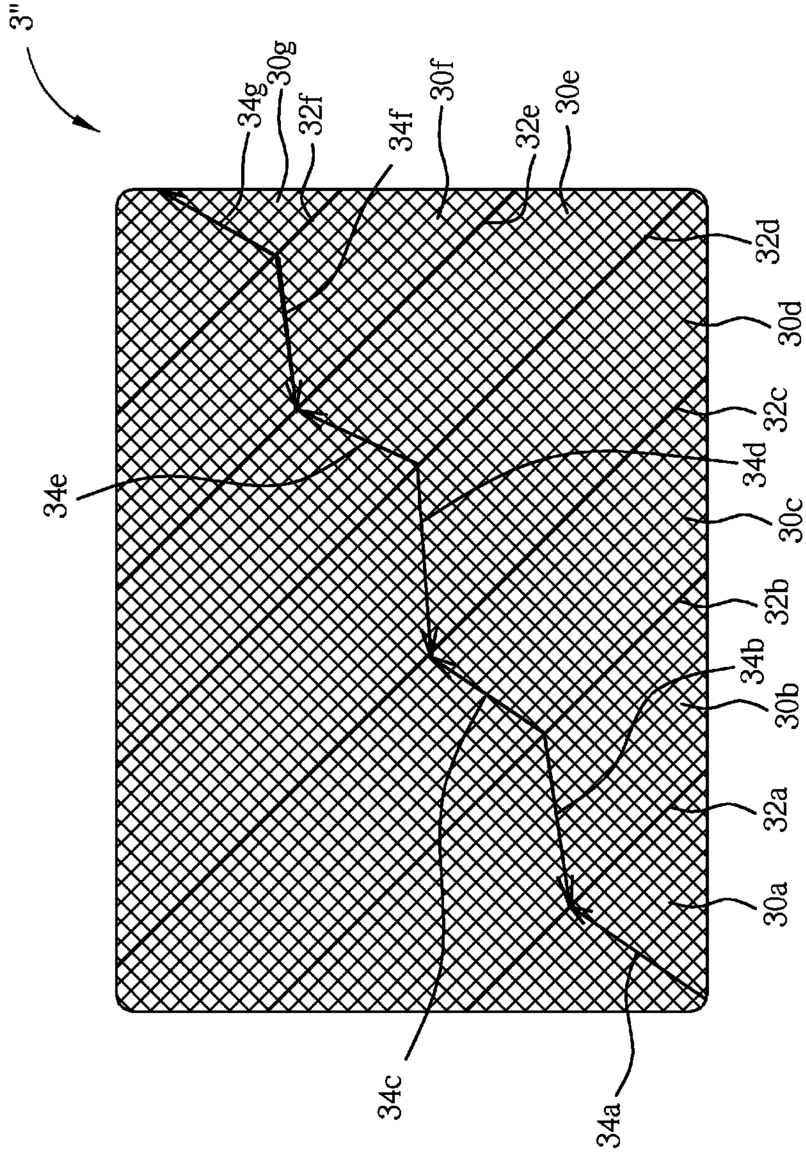

3"
34g
30g
32f
34f
30f
32e
30e
32d
30d
32c
34d
30c
32b
34b
30b
32a
30a
34e
34c
34a

FIG. 6

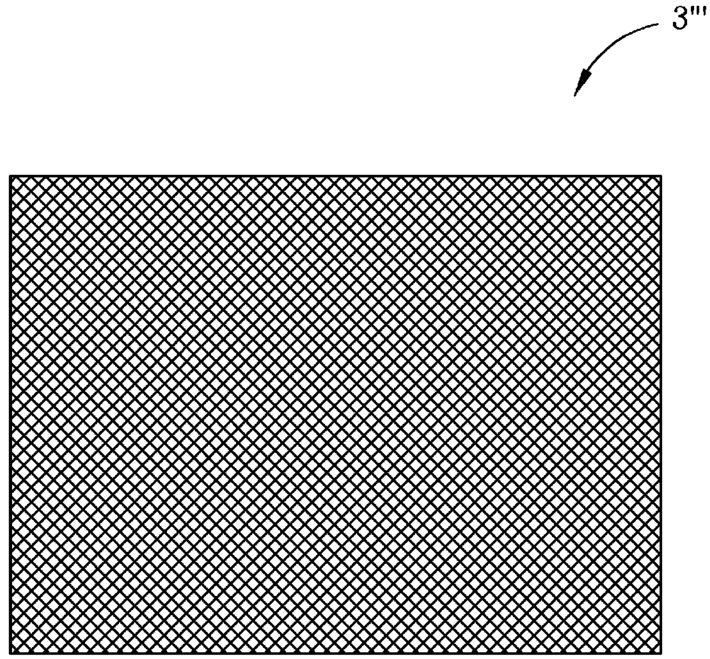


FIG. 7

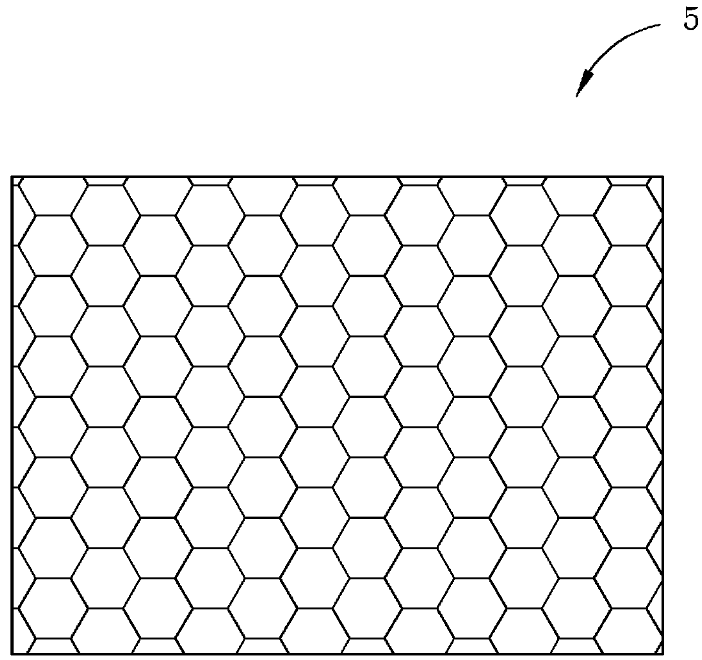


FIG. 8

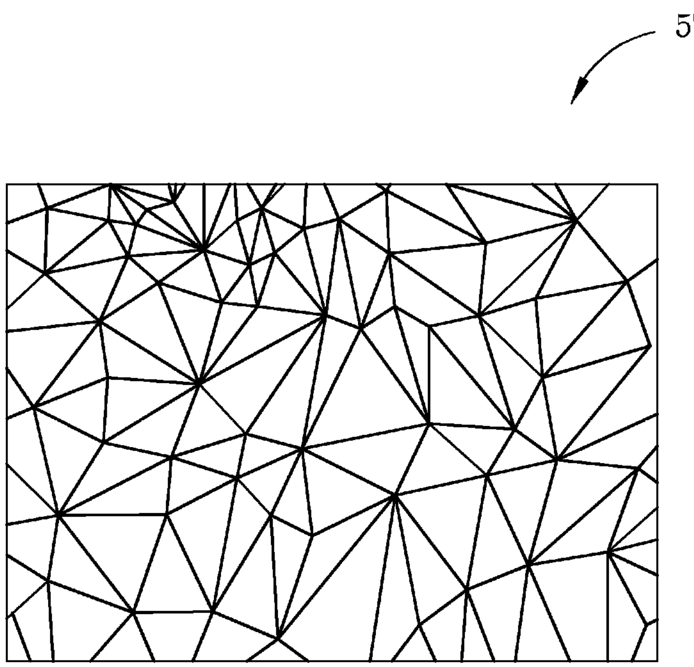


FIG. 9

MOLD MACHINING METHOD AND MOLD MACHINING SYSTEM FOR COMPUTER NUMERICAL CONTROL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The disclosure relates to a mold machining method and a mold machining system and, more particularly, to a mold machining method and a mold machining system for computer numerical control.

2. Description of the Prior Art

In general, a computer numerical control (CNC) system can be used to form a 3D pattern on a plastic injection mold. In the CNC system, numerical control (NC) instructions are inputted into a memory of a numerical control system and compiled by the computer and then a 2D or 3D file is transmitted to a driver for driving a motor to cut a surface of a mold, so as to form a 3D pattern with different depths and curved surfaces on the surface of the mold.

Referring to FIG. **1**, FIG. **1** is a flowchart illustrating a CNC machining process of the prior art. As shown in FIG. **1**, the conventional CNC machining process performs step S**100** first to establish a 3D pattern by computer aided design (CAD) software. Afterward, step S**102** is performed to plan machining process by computer aided manufacturing (CAM) software. Step S**104** is then performed to rough machine a mold material by a CNC machine. Finally, step S**106** is performed to fine machine the mold material by the CNC machine. However, the conventional CNC machining process always has the following problems.

1) If only one cutting tool is used to machine a mold with a 3D pattern larger than 10000 mm^2, there will be obvious cutting marks formed on the mold due to worn cutting tool such that the appearance of a product made by the mold will not have uniform gloss;

2) After changing the worn cutting tool by a new cutting tool, the appearance of a product made by the mold will have obvious tool marks and will not have uniform gloss;

3) After machining the mold, the mold has to be polished manually due to uneven surface without high gloss such that crest lines of the 3D pattern may deform and refraction angles may be disordered; and

4) After machining the mold, the mold has to be sprayed with paint or sand so as to modify tool marks such that the labor hour and cost will increase due to secondary processing and the appearance of a product made by the mold will not have high gloss.

SUMMARY OF THE INVENTION

The disclosure provides a mold machining method and a mold machining system for computer numerical control so as to solve the aforesaid problems.

According to an embodiment of the disclosure, a mold machining method for computer numerical control comprises steps of establishing a 3D pattern; performing an initial machining process on a mold material by the 3D pattern; calculating a total machining area corresponding to the 3D pattern; dividing the 3D pattern into a plurality of precise machining regions according to the total machining area and a predetermined machining area and enabling a boundary line between every two adjacent precise machining regions to be corresponding to a crest line of the 3D pattern; and performing a precise machining process on each of the precise

machining regions and changing a cutting tool at the boundary line between every two adjacent precise machining regions.

In this embodiment, cutting directions of two adjacent precise machining regions are opposite to each other.

In this embodiment, the cutting tool is fed or retracted at the boundary line between every two adjacent precise machining regions.

In this embodiment, the boundary line between every two adjacent precise machining regions is corresponding to a highest line of the 3D pattern.

According to another embodiment of the disclosure, a mold machining system for computer numerical control comprises a pattern establishing module, a calculating module, a region dividing module and a machining module. The pattern establishing module is used for establishing a 3D pattern. The calculating module is used for calculating a total machining area corresponding to the 3D pattern. The region dividing module is used for dividing the 3D pattern into a plurality of precise machining regions according to the total machining area and a predetermined machining area and enabling a boundary line between every two adjacent precise machining regions to be corresponding to a crest line of the 3D pattern. The machining module is used for performing an initial machining process on a mold material by the 3D pattern after the 3D pattern is established and performing a precise machining process on each of the precise machining regions after the precise machining regions are obtained, wherein the machining module changes a cutting tool at the boundary line between every two adjacent precise machining regions.

In this embodiment, cutting directions of two adjacent precise machining regions are opposite to each other.

In this embodiment, the cutting tool is fed or retracted at the boundary line between every two adjacent precise machining regions.

In this embodiment, the boundary line between every two adjacent precise machining regions is corresponding to a highest line of the 3D pattern.

According to another embodiment of the disclosure, a mold machining method for computer numerical control comprises steps of establishing a 3D pattern; performing an initial machining process on a mold material by the 3D pattern; and feeding a cutting tool at a position corresponding to a crest line of the 3D pattern so as to perform a precise machining process on the mold material.

As mentioned in the above, the disclosure divides the 3D pattern into a plurality of precise machining regions according to the total machining area and the predetermined machining area and enables the boundary line between every two adjacent precise machining regions to be corresponding to the crest line of the 3D pattern. After performing the precise machining process on each of the precise machining regions, the disclosure changes the cutting tool at the boundary line between every two adjacent precise machining regions. Since the boundary line between every two adjacent precise machining regions is corresponding to the crest line of the 3D pattern (i.e. the highest line of the 3D pattern), the position where the cutting tool is changed is corresponding to a lowest position of a pattern formed on a surface of a product such that tool marks will not be seen by a user due to scatteration of light. Furthermore, since the cutting tool is fed or retracted at the boundary line between every two adjacent precise machining regions (i.e. the cutting tool is fed or retracted at the same position between every two adjacent precise machining regions), tool marks formed by worn cutting tool are unobvious. If the total machining area is smaller than the predetermined machining area, the disclosure may feed the cutting tool at the position corresponding to the crest line of the 3D pattern so as to perform the precise machining process on the mold material immediately without defining the aforesaid precise machining regions. Accordingly, the appearance of a product made by the mold, which is machined by the disclosure, will have no tool marks and have high gloss so as to render the design of the 3D pattern authentically. Moreover, the disclosure does not need polishing process and can reduce labor hour so as to enhance economic benefits.

These and other objectives of the present disclosure will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a flowchart illustrating a CNC machining process of the prior art.

FIG. **2** is a functional block diagram illustrating a mold machining system for computer numerical control according to an embodiment of the disclosure.

FIG. **3** is a flowchart illustrating a mold machining method for computer numerical control according to an embodiment of the disclosure.

FIG. **4** is a schematic diagram illustrating a 3D pattern.

FIG. **5** is a schematic diagram illustrating another 3D pattern.

FIG. **6** is a schematic diagram illustrating another 3D pattern.

FIG. **7** is a schematic diagram illustrating another 3D pattern.

FIG. **8** is a schematic diagram illustrating a mold manufactured by the mold machining method of the disclosure.

FIG. **9** is a schematic diagram illustrating another mold manufactured by the mold machining method of the disclosure.

DETAILED DESCRIPTION

Referring to FIGS. **2** to **4**, FIG. **2** is a functional block diagram illustrating a mold machining system **1** for computer numerical control according to an embodiment of the disclosure, FIG. **3** is a flowchart illustrating a mold machining method for computer numerical control according to an embodiment of the disclosure, and FIG. **4** is a schematic diagram illustrating a 3D pattern **3**. The mold machining method shown in FIG. **3** can be implemented by the mold machining system **1** shown in FIG. **2**. In practical applications, the mold machining system **1** shown in FIG. **2** and the mold machining method shown in FIG. **3** can be embedded in a computer numerical control (CNC) machine.

As shown in FIG. **2**, the mold machining system **1** comprises a pattern establishing module **10**, a calculating module **12**, a region dividing module **14** and a machining module **16**. In this embodiment, the pattern establishing module **10**, the calculating module **12**, the region dividing module **14** and the machining module **16** may be implemented by software, hardware or the combination thereof.

When the mold machining system **1** shown in FIG. **2** and the mold machining method shown in FIG. **3** are used to machine a mold, first of all, step S**200** is performed to establish a 3D pattern **3** (as shown in FIG. **4**) by the pattern establishing module **10**. In practical applications, the pattern establishing module **10** may use computer aided design (CAD) software to establish the 3D pattern **3**. Afterward, step S**202** is performed to plan machining process using computer aided manufacturing (CAM) software by the pattern establishing module **10**. Step S**204** is then performed to check whether the precision of the 3D pattern **3** has a defect by the pattern establishing module **10**. If the precision of the 3D pattern **3** has a defect (e.g. lines cross each other), step S**200** is performed again to reestablish the 3D pattern **3**. If the precision of the 3D pattern **3** has no defect, step S**206** is then performed to select a cutting tool, which is suitable for machining a mold material, according to the mold material by the machining module **16**. For example, if the mold material is steel, the cutting tool may be tungsten steel cutting tool correspondingly. In this embodiment, the machining module **16** performs an initial machining process on a mold material by the 3D pattern **3** after the 3D pattern **3** is established. The aforesaid initial machining process may comprise steps S**208** and S**210** shown in FIG. **3**, wherein step S**208** is performed to rough machine the mold material using the 3D pattern **3** by a CNC machine and step S**210** is performed to fine machine the mold material using the 3D pattern **3** by the CNC machine.

Then, step S**212** is performed to calculate a total machining area corresponding to the 3D pattern **3** by the calculating module **12**. Then, step S**214** is performed to divide the 3D pattern **3** into a plurality of precise machining regions according to the total machining area and a predetermined machining area and enable a boundary line between every two adjacent precise machining regions to be corresponding to a crest line of the 3D pattern **3** by the region dividing module **14**. For example, if the total machining area is 20000 mm^2 and the predetermined machining area is 10000 mm^2, the region dividing module **14** will divide the 3D pattern **3** into two precise machining regions **30***a*, **30***b* (as shown in FIG. **3**) and the boundary line **32** between the two adjacent precise machining regions **30***a*, **30***b* is corresponding to a crest line of the 3D pattern **3**. In this embodiment, the boundary line **32** between the two adjacent precise machining regions **30***a*, **30***b* is corresponding to a highest line of the 3D pattern **3**. Furthermore, an orientation of the boundary line **32** between the two adjacent precise machining regions **30***a*, **30***b* is 45 degrees, as shown in FIG. **4**.

After defining the precise machining regions **30***a*, **30***b*, step S**216** is performed to estimate the number and standard of needed cutting tools and define cutting directions **34***a*, **34***b* of the precise machining regions **30***a*, **30***b* by the machining module **16**. In this embodiment, the cutting directions **34***a*, **34***b* of the two adjacent precise machining regions **30***a*, **30***b* are opposite to each other and the cutting tool is fed or retracted at the boundary line **32** between the two adjacent precise machining regions **30***a*, **30***b*.

Then, step S**218** is performed to perform a precise machining process on each of the precise machining regions **30***a*, **30***b* and change the cutting tool at the boundary line **32** between the two adjacent precise machining regions **30***a*, **30***b* by the machining module **16**. For example, the machining module **16** may perform the precise machining process on the precise machining region **30***a* along the cutting direction **34***a* first. After machining the precise machining region **30***a*, the machining module **16** retracts the cutting tool at the boundary line **32** so as to change the cutting tool. Afterward, the machining module **16** performs the precise machining process on the precise machining region **30***b* along the cutting direction **34***b*. After machining the precise machining region **30***b*, the machining module **16** also retracts the cutting tool at the boundary line **32**. It should be noted that the machining module **16** may also feed the cutting tool at the boundary line **32** and perform the precise machining process on the precise machining regions **30***a*, **30***b* along reverse directions of the cutting directions **34***a*, **34***b*.

Since the boundary line **32** between the two adjacent precise machining regions **30***a*, **30***b* is corresponding to the crest line of the 3D pattern **3** (i.e. the highest line of the 3D pattern **3**), the position where the cutting tool is changed is corresponding to a lowest position of a pattern formed on a surface of a product such that tool marks will not be seen by a user due to scatteration of light. Furthermore, since the cutting tool is fed or retracted at the boundary line **32** between the two adjacent precise machining regions **30***a*, **30***b* (i.e. the cutting tool is fed or retracted at the same position between every two adjacent precise machining regions), tool marks formed by worn cutting tool are unobvious. Moreover, the disclosure may obtain better surface effect when the orientation of the boundary line **32** is 45 degrees as shown in FIG. **4**.

Referring to FIG. **5**, FIG. **5** is a schematic diagram illustrating another 3D pattern **3'**. The main difference between the 3D pattern **3'** and the aforesaid 3D pattern **3** is that there is a characteristic pattern **36** in the 3D pattern **3'**. If there is a characteristic pattern **36** in the 3D pattern **3'**, the region dividing module **14** will take the characteristic pattern **36** to be an individual precise machining region. In this embodiment, the characteristic pattern **36** may be a pattern consisting of a plurality of complicated lines. It should be noted that the process of using the 3D pattern **3'** to machine a mold material is substantially the same as the aforesaid process and it will not be depicted herein again.

Referring to FIG. **6**, FIG. **6** is a schematic diagram illustrating another 3D pattern **3"**. The main difference between the 3D pattern **3"** and the aforesaid 3D pattern **3** is that the 3D pattern **3"** is divided into seven precise machining regions **30***a*-**30***g*. As shown in FIG. **6**, cutting directions **34***a*-**34***g* of every two adjacent precise machining regions **30***a*-**30***g* are opposite to each other. Furthermore, the cutting tool is fed or retracted at the boundary lines **32***a*-**32***f* between every two adjacent precise machining regions **30***a*-**30***g* (e.g. the cutting tool is fed or retracted at the boundary line **32***a* between the two adjacent precise machining regions **30***a*, **30***b*; the cutting tool is fed or retracted at the boundary line **32***b* between the two adjacent precise machining regions **30***b*, **30***c*; and so on). Moreover, the machining module **16** changes the cutting tool at the boundary lines **32***a*-**32***f* between every two adjacent precise machining regions **30***a*-**30***g*. It should be noted that the process of using the 3D pattern **3"** to machine a mold material is substantially the same as the aforesaid process and it will not be depicted herein again.

Referring to FIG. **7**, FIG. **7** is a schematic diagram illustrating another 3D pattern **3'''**. The main difference between the 3D pattern **3'''** and the aforesaid 3D pattern **3** is that the 3D pattern **3'''** does not be divided into a plurality of precise machining regions. If the total machining area (e.g. 5000 mm^2) is smaller than the predetermined machining area (e.g. 10000 mm^2), the disclosure can feed a cutting tool at a position corresponding to a crest line of the 3D pattern **3'''** so as to perform a precise machining process on the mold material immediately without defining the aforesaid precise machining regions. In other words, the whole of the 3D pattern **3'''** is taken as one single precise machining region. It should be noted that the process of using the 3D pattern **3'''** to machine a mold material is substantially the same as the aforesaid process and it will not be depicted herein again.

Referring to FIGS. **8** and **9**, FIG. **8** is a schematic diagram illustrating a mold **5** manufactured by the mold machining method of the disclosure, and FIG. **9** is a schematic diagram illustrating another mold **5'** manufactured by the mold machining method of the disclosure. As shown in FIG. **8**, a 3D pattern formed on a surface of the mold **5** is regular. As shown in FIG. **9**, a 3D pattern formed on a surface of the mold **5'** is irregular. In other words, the mold machining method and the mold machining system **1** of the disclosure can form any types of 3D patterns on a mold.

As mentioned in the above, the disclosure divides the 3D pattern into a plurality of precise machining regions according to the total machining area and the predetermined machining area and enables the boundary line between every two adjacent precise machining regions to be corresponding to the crest line of the 3D pattern. After performing the precise machining process on each of the precise machining regions, the disclosure changes the cutting tool at the boundary line between every two adjacent precise machining regions. Since the boundary line between every two adjacent precise machining regions is corresponding to the crest line of the 3D pattern (i.e. the highest line of the 3D pattern), the position where the cutting tool is changed is corresponding to a lowest position of a pattern formed on a surface of a product such that tool marks will not be seen by a user due to scatteration of light. Furthermore, since the cutting tool is fed or retracted at the boundary line between every two adjacent precise machining regions (i.e. the cutting tool is fed or retracted at the same position between every two adjacent precise machining regions), tool marks formed by worn cutting tool are unobvious. If the total machining area is smaller than the predetermined machining area, the disclosure may feed the cutting tool at the position corresponding to the crest line of the 3D pattern so as to perform the precise machining process on the mold material immediately without defining the aforesaid precise machining regions. Accordingly, the appearance of a product made by the mold, which is machined by the disclosure, will have no tool marks and have high gloss so as to render the design of the 3D pattern authentically. Moreover, the disclosure does not need polishing process and can reduce labor hour so as to enhance economic benefits.

Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the disclosure. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. A mold machining method for computer numerical control comprising:

establishing a 3D pattern;

performing an initial machining process on a mold material by the 3D pattern;

calculating a total machining area corresponding to the 3D pattern;

dividing the 3D pattern into a plurality of precise machining regions according to the total machining area and a predetermined machining area and enabling a boundary line between every two adjacent precise machining regions to be corresponding to a crest line of the 3D pattern; and

performing a precise machining process on each of the precise machining regions and changing a cutting tool at the boundary line between every two adjacent precise machining regions;

wherein cutting directions of two adjacent precise machining regions are opposite to each other, an orientation of the boundary line between every two adjacent precise machining regions is 45 degrees, and the boundary line between every two adjacent precise machining regions is corresponding to a highest line of the 3D pattern.

2. The mold machining method for computer numerical control of claim **1**, wherein the cutting tool is fed or retracted at the boundary line between every two adjacent precise machining regions.

3. The mold machining method for computer numerical control of claim 1, further comprising:

selecting the cutting tool, which is suitable for machining the mold material, according to the mold material.

4. The mold machining method for computer numerical control of claim 1, further comprising:

if there is a characteristic pattern in the 3D pattern, taking the characteristic pattern to be an individual precise machining region.

5. A mold machining system for computer numerical control comprising:

a pattern establishing module for establishing a 3D pattern;

a calculating module for calculating a total machining area corresponding to the 3D pattern;

a region dividing module for dividing the 3D pattern into a plurality of precise machining regions according to the total machining area and a predetermined machining area and enabling a boundary line between every two adjacent precise machining regions to be corresponding to a crest line of the 3D pattern; and

a machining module for performing an initial machining process on a mold material by the 3D pattern after the 3D pattern is established and performing a precise machining process on each of the precise machining regions after the precise machining regions are obtained, wherein the machining module changes a cutting tool at the boundary line between every two adjacent precise machining regions;

wherein cutting directions of two adjacent precise machining regions are opposite to each other, an orientation of the boundary line between every two adjacent precise machining regions is 45 degrees, and the boundary line between every two adjacent precise machining regions is corresponding to a highest line of the 3D pattern.

6. The mold machining system for computer numerical control of claim 5, wherein the cutting tool is fed or retracted at the boundary line between every two adjacent precise machining regions.

7. The mold machining system for computer numerical control of claim 5, wherein the machining module selects the cutting tool, which is suitable for machining the mold material, according to the mold material.

8. The mold machining system for computer numerical control of claim 5, wherein if there is a characteristic pattern in the 3D pattern, the region dividing module takes the characteristic pattern to be an individual precise machining region.

* * * * *